



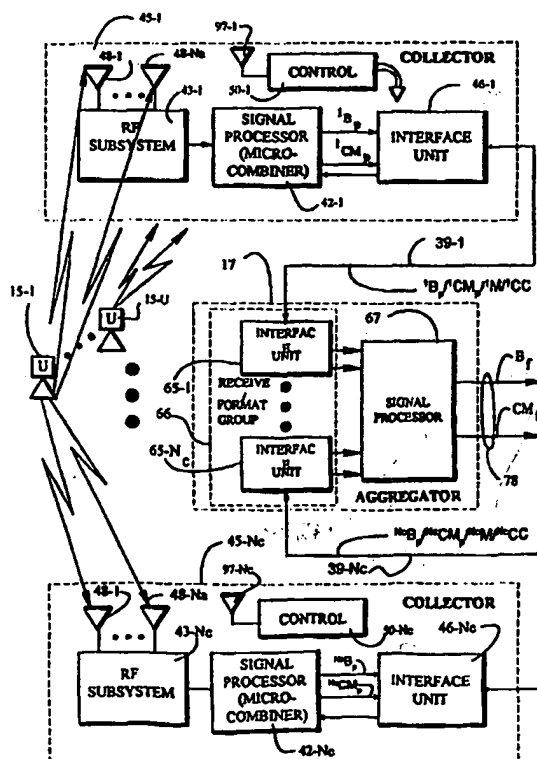
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<p>(21) International Application Number: PCT/US99/01931</p> <p>(22) International Filing Date: 29 January 1999 (29.01.99)</p> <p>(30) Priority Data: 09/017,189 2 February 1998 (02.02.98) US</p> <p>(71) Applicant: SILICON WIRELESS LIMITED [US/US]; 2025 Garcia Avenue, Mountain View, CA 94043-1139 (US).</p> <p>(72) Inventors: McLAUGHLIN, Michael, David; 20561 Montalvo Lane, Saratoga, CA 95070 (US). RAACK, Kevin, Dean; 2010 Lynn Avenue, Los Gatos, CA 95032 (US). VASTANO, John, Andrew; 3497 Cabrillo Avenue, Santa Clara, CA 95051 (US). WALLERIUS, John, Walker; 4938 Wheeler Drive, Fremont, CA 94538 (US). SMITH, Bruce, Denis; 238 Oak Grove Avenue, Atherton, CA 94027 (US). HOWARD, David, Amundson; 7601 Aspen Place, Newark, CA 94560 (US). COATES, Karen, Evelyn; 5674 Brookhurst Court, San Jose, CA 95129 (US).</p> <p>(74) Agent: LOVEJOY, David, E.; Fliesler Dubb Meyer and Lovejoy LLP, Suite 400, Four Embarcadero Center, San Francisco, CA 94111-4156 (US).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published</p> <p><i>With international search report.</i></p> <p><i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: METHOD AND APPARATUS FOR COLLECTOR ARRAYS IN WIRELESS COMMUNICATIONS SYSTEMS

(57) Abstract

The present invention is a communication system having a plurality of forward channel communications and a plurality of corresponding reverse channel communications in a region for communications with cellular users. Each region includes a plurality of zone managers. Each zone manager includes a broadcaster having a broadcaster transmitter for broadcasting a plurality of forward channel communications using broadband broadcaster signals to form a plurality of broadcaster forward channels. Each zone manager includes an aggregator for processing reverse channel communications. Each zone manager communicates with a collector group for receiving reverse channel communications from users and forwarding reverse channel communications to the aggregator. Each of the users includes a user receiver for receiving a different forward channel from said broadcaster and includes user transmitter means for broadcasting user reverse channel communications in a different user reverse channel. The collector group for each zone manager is formed of macro-diverse collectors some of which are located at other zone managers. By having collectors co-sited at zone manager sites, the macro-diverse collector operations are possible while reducing the installation cost of collectors.



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TITLE**METHOD AND APPARATUS FOR COLLECTOR ARRAYS IN
WIRELESS COMMUNICATIONS SYSTEMS****Cross-Reference to Related Applications**

5 This application is a continuation-in-part of application SC/Serial No.
08/866,700 filed on May 30, 1997 entitled METHOD AND APPARATUS
FOR WIRELESS COMMUNICATION EMPLOYING CONFIDENCE
METRIC PROCESSING FOR BANDWIDTH REDUCTION, assigned to the
same assignee as this application.

10 This application is a continuation-in-part of application SC/Serial No.
08/801,711 filed February 14, 1997 entitled METHOD AND APPARATUS
FOR WIRELESS COMMUNICATION EMPLOYING AGGREGATION
FOR DIGITAL SIGNALS, assigned to the same assignee as this application.

15 This application is a continuation-in-part of application SC/Serial No.
08/544,913 filed October 18, 1995 entitled METHOD AND APPARATUS
FOR WIRELESS COMMUNICATION EMPLOYING COLLECTOR
ARRAYS, assigned to the same assignee as this application.

20 This application is a continuation-in-part of application SC/Serial No.
08/634,141 filed April 19, 1996 entitled METHOD AND APPARATUS
FOR TDMA WIRELESS COMMUNICATION EMPLOYING
COLLECTOR ARRAYS FOR RANGE EXTENSION, assigned to the same
assignee as this application.

25 This application is a continuation-in-part of application SC/Serial No.
08/889,881 filed July 3, 1997 entitled METHOD AND APPARATUS FOR
WIRELESS COMMUNICATION EMPLOYING CONTROL FOR
CONFIDENCE METRIC BANDWIDTH REDUCTION, assigned to the
same assignee as this application.

Background of the Invention

The present invention relates to the field of two-way wireless communications systems and more specifically to methods and apparatus using collector arrays in cellular systems.

Cellular Systems

5 Present day cellular mobile telephone systems developed due to a large demand for mobile services that could not be satisfied by earlier systems. Cellular systems "reuse" frequency and other radio frequency (RF) resources within a group of cells to provide wireless two-way communication to large numbers of users. Each cell covers a small geographic area and
10 collectively a group of adjacent cells covers a larger geographic region. Each cell has a fraction of the total amount of the RF spectrum or other resource available to support cellular users. Cells are of different sizes (for example, macro-cell or micro-cell) and are generally fixed in capacity. The actual shapes and sizes of cells are complex functions of the terrain, the man-made
15 environment, the quality of communication and the user capacity required. Cells are connected to each other via land lines or microwave links and to the public-switched telephone network (PSTN) through telephone switches that are adapted for mobile communication. The switches provide for the hand-off of users from cell to cell as mobile users move between cells.

20 In conventional cellular systems, each cell has a base station with RF transmitters and RF receivers co-sited for transmitting and receiving communications to and from cellular users in the cell. The base station transmits forward channel communications to users and receives reverse channel communications from users in the cell.

25 The forward and reverse channel communications use separate channel resources, such as frequency bands or spreading codes, so that simultaneous transmissions in both directions are possible. With separate

frequency bands, this operation is referred to as frequency division duplex (FDD) signaling. In time division duplex (TDD) signaling, the forward and reverse channels take turns using the same frequency band. In code division duplex (CDD), the signaling is spread across a wide spectrum of frequencies and the signals are distinguished by different codes.

5 The base station in addition to providing RF connectivity to users also provides connectivity to a Mobile Telephone Switching Office (MTSO) or Mobile Switching Center (MSC). In a typical cellular system, one or more MTSO's (MSC's) will be used over the covered region. Each MTSO (MSC) can service a number of base stations (which are also known as Base
10 Transceiver Stations (BTS)) and associated cells in the cellular system and supports switching operations for routing calls between other systems (such as the PSTN) and the cellular system or for routing calls within the cellular system.

15 Base stations are typically controlled from the MTSO by means of a Base Station Controller (BSC). The BSC assigns RF carriers or other resources to support calls, coordinates the handoff of mobile users between base stations, and monitors and reports on the status of base stations. The number of base stations controlled by a single MTSO depends upon the traffic at each base station, the cost of interconnection between the MTSO
20 and the base stations, the topology of the service area and other similar factors.

25 A *handoff* is a communication transfer for a particular user from one base station in one cell to another base station in another cell. A *handoff* between base stations occurs, for example, when a mobile user travels from a first cell to an adjacent second cell. *Handoffs* also occur to relieve the load on a base station that has exhausted its traffic-carrying capacity or where poor quality communication is occurring. During the *handoff* in conventional cellular systems, there may be a transfer period of time during which the

forward and reverse communications to the mobile user are severed with the base station for the first cell and are not yet established with the second cell.

Cellular Architectures

In wireless systems, both *physical channels* and *logical channels* exist where *logical channels* carry signaling data or user data that is mapped onto *physical channels*. In cellular systems, *traffic channels* are logical channels for user data and are distinguished from *control channels* that are logical channels for network management messages, maintenance, operational tasks and other control information used to move traffic data reliably and efficiently in the system. In general, the term *channels* refers to *logical channels* unless the context indicates otherwise and those logical channels are understood to be mapped to physical channels. The control channels process the access requests of mobile users.

Conventional cellular implementations employ one of several techniques to allocate RF resources from cell to cell over the cellular domain. Since the power at a receiver of a radio signal fades as the distance between transmitter and receiver increases, power fading is relied upon to enable RF resource reuse in cellular systems. In a cellular system, potentially interfering transmitters that are far enough away from a particular receiver, and which transmit with acceptable transmission parameters, do not unacceptably interfere with reception at the particular receiver.

In a frequency division multiple access (FDMA) system, a communications channel consists of an assigned frequency and bandwidth (carrier). If a carrier is in use in a given cell, it can only be reused in other cells sufficiently separated from the given cell so that the other cell signals do not significantly interfere with the carrier in the given cell. The determination of how far away reuse cells must be and of what constitutes significant interference are implementation-specific details.

In a time division multiple access (TDMA) system, time is divided into time slots of a specified duration. Time slots are grouped into frames, and the homologous time slots in each frame are assigned to the same channel. It is common practice to refer to the set of homologous time slots over all frames as a time slot. Typically, each logical channel is assigned a time slot or slots on a common carrier band. The radio transmissions carrying the communications over each logical channel are thus discontinuous in time. The radio transmitter is *on* during the time slots allocated to it and is *off* during the time slots not allocated to it. Each separate radio transmission which occupies a single time slot is called a burst. Each TDMA implementation defines one or more burst structures. Typically, there are at least two burst structures, namely, a first one for the user access request to the system, and a second one for routine communications once a user has been registered. Strict timing must be maintained in TDMA systems to prevent the bursts comprising one logical channel from interfering with the bursts comprising other logical channels in adjacent time slots.

One example of a TDMA system is a GSM system. In GSM systems, in addition to traffic channels, there are four different classes of control channels, namely, *broadcast channels*, *common control channels*, *dedicated control channels*, and *associated control channels* that are used in connection with access processing and user registration.

In a code division multiple access (CDMA) system, the RF transmissions are forward channel communications and reverse channel communications that are spread over a wide spectrum (spread spectrum) with unique spreading codes. The RF receptions in such a system distinguish the emissions of a particular transmitter from those of many others in the same spectrum by processing the whole occupied spectrum in careful time coincidence. The desired signal in an emission is recovered by de-spreading

the signal with a copy of the spreading code in the receiving correlator while all other signals remain fully spread and are not subject to demodulation.

The CDMA *forward physical channel* transmitted from a base station in a cell site is a *forward waveform* that includes individual logical channels that are distinguished from each other by their spreading codes (and are not
5 separated in frequency or time as is the case with GSM). The forward waveform includes a *pilot channel*, a *synchronization channel* and *traffic channels*.

Timing is critical for proper de-spreading and demodulation of CDMA signals and the mobile users employ the pilot channel to synchronize with the
10 base station so the users can recognize any of the other channels. The synchronization channel contains information needed by mobile users in a CDMA system including the system identification number (SID), access procedures and precise time-of-day information.

Spread spectrum communication protocols include but are not limited
15 to CDMA as well as Frequency Hopping and Time Hopping techniques. Frequency Hopping involves the partitioning of the frequency bandwidth into smaller frequency components, which a channel then uses by hopping from one frequency component to another in an essentially random manner. Interchannel distortion acts essentially as
20 Gaussian white noise across time for each channel. Time Hopping involves a time division scheme wherein each channel starts and stops at differing time slots in an essentially random fashion. Again, interchannel distortion acts essentially as Gaussian white noise across time for each channel.

Applicable communications protocols of this patent include but are
25 not limited to FDMA, TDMA, and spread spectrum techniques, as well as protocols employing techniques of more than one of FDMA, TDMA and spread spectrum techniques.

Many cellular systems are inherently space division multiple access (SDMA) systems in which each cell occupies and operates in a zone within a larger region. Also, cell sectoring, microcells and narrow beam antennas all employ spacial divisions that are useful in optimizing the reuse of RF resources.

5 Space Diversity

The combining of signals from a single source that are received at multiple spaced-apart antennas is called space diversity. Micro-diversity is one form of space diversity that exists when two or more receiving antennas are located in close proximity to each other (within a distance of several
10 meters for example) and where each antenna receives the signals from the single source. In micro-diversity systems, the received signals from the common source are processed and combined to form an improved quality resultant signal for that single source. Micro-diversity is effective against Rayleigh or Rician fading or similar disturbances. The terminology *micro-*
15 *-diverse locations* means, therefore, the locations of antennas that are close together and that are only separated enough to be effective against Rayleigh or Rician fading or similar disturbances. The signal processing for micro-diverse locations can occur at a single physical location and hence micro-diversity processing need not adversely impact reverse channel bandwidth
20 requirements.

Macro-diversity is another form of space diversity that exists when two or more receiving antennas are located far apart from each other (at a distance much greater than several meters, for example, several kilometers) and where each antenna receives the signals from the single source. In
25 macro-diversity systems, the received signals from the single source are processed and combined to form an improved quality resultant signal for that single source. The terminology *macro-diversity* means that the antennas are

far enough apart to have de-correlation between the mean signal levels for signals from the single source. The terminology *macro-diverse locations* means, therefore, the locations of antennas that are far enough apart to achieve that de-correlation. Macro-diversity processing involves forwarding of signals to a common processing location and hence consumes
5 communication bandwidth.

The mean signal levels in macro-diversity systems are de-correlated because each separate signal path has unique propagation properties that diminish the signal strength. The propagation properties in each path are different from those in each other signal path. These unique propagation
10 properties vary with distances above Rayleigh or Rician fading distances and are due to terrain effects, signal blocking by structures or vegetation and other similar environmental factors. Fading due to such factors is referred to as *shadow fading*. De-correlation distances for shadow fading may be just above Rayleigh fading distances and may be as large as several kilometers.

15 User Location In Cellular Systems

In cellular systems, equipment and functions are distributed over zones, cells, and other coverage areas. In order to control and operate cellular systems efficiently, information about the location of active users in the system is increasingly important.

20 In conventional cellular systems, the user location information that has been used has included the cell, or sector of a cell, in which a user is located. The location of a user in a cellular system is important because of the fading of signals as a function of the distance of a receiver from a transmitter. Although increases in broadcast power can be used at greater
25 distances between broadcasters and receivers, such increases tend to cause reception interference by other receivers and hence tend to reduce the user capacity of the system. Accordingly, cellular systems balance RF resources in

order to optimize parameters that efficiently establish good system performance.

The problem associated with increases in capacity of cellular systems have created a need for improved methods and apparatus for use in wireless mobile communication systems.

5

Summary of the Invention

The present invention is a communication system having a plurality of forward channel communications and a plurality of corresponding reverse channel communications in a region for communications with cellular users. Each region includes a plurality of zone managers. Each zone manager
10 includes a broadcaster having a broadcaster transmitter for broadcasting a plurality of forward channel communications using broadband broadcaster signals to form a plurality of broadcaster forward channels. Each zone manager includes an aggregator for processing reverse channel communications. Each zone manager communicates with a collector group for
15 receiving reverse channel communications from users and forwarding reverse channel communications to the aggregator. Each of the users includes a user receiver for receiving a different forward channel from said broadcaster and includes user transmitter means for broadcasting user reverse channel communications in a different user reverse channel.

20

The collector group for each zone manager is formed of macro-diverse collectors some of which are located at other zone managers. By having collectors co-sited at zone manager sites, the macro-diverse collector operations are possible while reducing the installation cost of collectors. The foregoing and other objects, features and advantages of the invention will be
25 apparent from the following detailed description in conjunction with the drawings.

Brief Description of the Drawings

FIG. 1 depicts a communication system for wireless users employing macro-diverse collectors for receiving user access requests for processing and forwarding to an aggregator for combining.

5 FIG. 2 depicts a representation of multiple zones of the FIG. 1 type forming a hex zone in a cellular system.

FIG. 3 depicts a representation of multiple hex zones of the FIG. 2 type.

FIG. 4 depicts further details of the users, a plurality of collectors and an aggregator for the communication system of FIG. 1.

10 FIG. 5 depicts a block diagram representation of a region of collectors co-sited with zone managers.

FIG. 6 depicts a block diagram representation of a zone manager communication layout for the region of FIG. 5.

15 FIG. 7 depicts a block diagram representation of typical zone manager.

FIG. 8 depicts a region manager and constituent zone managers and their primary resources.

Detailed Description of the Invention

Cellular System -- FIG. 1

20 In FIG. 1, a cellular system is shown having a zone manager 20 that includes broadcaster (B)16, aggregator (A)17 and zone control (ZC) 18. The broadcaster 16 broadcasts forward channel (FC) communications from broadcaster 16 to multiple users 15 including users U1, U2, ..., UU located within a broadcaster zone 5 designated by the dashed-line triangle. The users
25 15 can be at fixed locations or can be mobile. Each of the multiple users 15 transmits reverse channel (RC) communications to one or more of multiple collectors 45 including collectors C1, C2, C3, C4, C5, ..., C_{Nc} which, when

active, in turn forward the reverse channel communications to aggregator 17 in zone manager 20. The broadcaster 16, the aggregator 17 and the zone control 18 can be co-sited or at different locations. The determination of which ones of the collectors 45 are active for any particular user 15 is under control of zone control 18. Zone control 18 operates to select active collectors based upon bandwidth availability, signal quality and other system parameters. For purposes of explanation in this application, it is assumed that collectors C1, C2 and C3 have been selected for user U1.

Each of the users 15 has a receiver for receiving broadcasts on the forward channels from the broadcaster 16. Also, each of the users 15 has a transmitter that transmits on reverse channels to the collectors 45. The collectors 45 are sited at *macro-diverse locations* relative to each other generally within broadcaster zone 5. Therefore, multiple copies of macro-diverse reverse channel communications are received at the aggregator 17 for each user 15.

In the FIG. 1 system, when any user 15 is turned from *off* to *on* in zone 5, an access protocol is followed in order that the user becomes recognized and registered for operations in the system. First, an orientation procedure is followed by user 15 to orient the user to zone manager 20 and any connected network such as the Public switched telephone network (PSTN). The user receives access synchronization signals from the broadcaster 16.

When a user 15 is turned from *off* to *on* in a broadcaster zone 5 and the orientation procedure has been followed, the user 15 sends access request bursts on an access reverse channel. Each burst includes a predetermined access request sequence of bits.

The collectors 45, distributed at macro-diverse locations, are time synchronized and receive the reverse channel signals with access request bursts from the users 15. The access requests from the users received at the macro-diverse collectors 45 are processed and forwarded to an aggregator 17 for final user registration processing.

In FIG. 1, the U1 user 15 is typical and receives forward channel (FC) communications including access synchronization information from broadcaster 16. The user 15 also forwards user-to-collector reverse channel communications (${}^{w/c}RC$) including user access requests to each of the collectors 45 and particularly to the active collectors C1, C2 and C3. Each of the active collectors C1, C2 and C3 for U1 forwards collector-to-aggregator reverse channel communications (${}^{c/a}RC_{U1}$) to aggregator 17. The reverse channel communications from the U1 user 15 include the user-to-collector communication ${}^{w/c}RC1_{U1}$ and the collector-to-aggregator communication ${}^{c/a}RC1$, the user-to-collector communication ${}^{w/c}RC2$ and the collector-to-aggregator communication ${}^{c/a}RC2$ and the user-to-collector communication ${}^{w/c}RC3_{U1}$ and the collector-to-aggregator communication ${}^{c/a}RC3$. Each of the other users U2, ..., UU in FIG. 1 has similar forward channel communications that include access synchronization signals and reverse channel communications that include user access requests.

In FIG. 1, the U1 users 15-1₁, ..., 15-1_{u1} are all located in a subregion bounded by the collector C1 and the arc 5₁ and hence are in close proximity to the collector C1. Because of the close proximity, the signal strength of the reverse channel transmissions from the U1 users 15-1₁, ..., 15-1_{u1} to collector C1 is normally high. Similarly, the U2 users 15-2₁, ..., 15-2_{u2} are all located in a subregion bounded by the collector C2 and the arc 5₂ and hence are in close proximity to the collector C2. Because of the close proximity, the signal strength of the reverse channel transmissions from the U2 users 15-2₁, ..., 15-2_{u2} to collector C2 is normally high. The U3 users 15-3₁, ..., 15-3_{u3} are all located in a subregion bounded by the collector C3 and the arc 5₃ and hence are in close proximity to the collector C3. The signal strength of the reverse channel transmissions from the U3 users 15-3₁, ..., 15-3_{u3} to collector C3 is normally high.

In FIG. 1, the central subregion 5_c generally bounded by the arcs 5_1 , 5_2 and 5_3 are relatively far from the collectors C1, C2 and C3 so that the reverse channel signal strength from all of the UU users 15- U_1 , ..., 15- U_{uu} in this region to each of the collectors C1, C2 and C3 is normally weaker than for users closer to the collectors in the subregions 5_1 , 5_2 and 5_3 .

5 The forward and reverse channel communications of FIG. 1 in the present invention apply to any digital radio signal system including, for example, TDMA, CDMA, SDMA and FDMA systems. If the digital radio signals of any particular system are not inherently burst structured, then some arbitrary partitioning of time into intervals may be used for processing in
10 accordance with the present invention.

Multiple Zone Configurations--FIG. 2 and FIG. 3

In FIG.2, the zones 5, including the zones 5-1, 5-2, ..., 5-6, are like the zone 5 of FIG. 1 and each zone 5 includes users 15 like those for zone 5-1. For example, zone 5-2 is adjacent to zone 5-1 and includes a C4 collector 45 that
15 operates together with at least the collectors C1 and C3 where collectors C1 and C3 also operate with zone 5-1.

In FIG.2, the cellular system is shown having zone managers 20-1, ..., 20-6 of which zone manager 20-1 is typical. The zone managers have
20 broadcasters 16-1, ..., 16-6, where broadcaster 16-1 is typical, that broadcast forward channel (FC) communications to multiple users 15 in one or more of the zones 5-1, ..., 5-6. Each of the users 15 transmits reverse channel (RC) communications to one or more of multiple collectors 45 including collectors C1, C2, C3 and C4, which in turn forward the reverse channel communications to aggregators 17-1, ..., 17-6, where aggregator 17-1 is typical. The zone
25 managers 20 can be located at a base station that is configured in a number of different ways. In one configuration, each broadcaster broadcasts forward channel communications in a different one of six sectors in six different

frequency ranges corresponding to the zones 5-1, 5-2, ..., 5-6. The users in the different zones transmit reverse channels on corresponding frequency ranges to the various collectors operating in their broadcast ranges and the collectors in turn forward reverse channel communications to a corresponding one of the aggregators 17. In another configuration, all of the zones use the same frequency ranges and no sectorization is employed and in such an embodiment one or more zone managers may be employed. In general, regardless of the configuration, some collector sites are associated with collectors for several zones. For example, C3 services users in two zones, 5-1 and 5-2. The backhaul link from C3 to the aggregator 17-1 is shared by users from zones 5-1 and 5-2.

In one embodiment in order to conserve bandwidth, the confidence metric bandwidth for one zone is at times reduced in order to permit an increase in the bandwidth of another zone where the zones are sharing reverse channel communication bandwidth from common associated collectors, like collectors C1 and C3 in the example described. Bandwidth control algorithms are stored and executed in each collector. Further, the zone manager 20 of FIG. 1 communicates with the processors 42 of FIG. 4 over remote interfaces when adjustments, such as for bandwidth balancing, are required.

In FIG.2, the region manager 12 controls the bandwidth allocation of the zone managers 20-1, ..., 20-6 for the contiguous regions 5-1, ..., 5-6 and for other regions which may or may not be contiguous to the regions 5-1, ..., 5-6.

In FIG. 3, the zones 5^1 , 5^2 , ..., 5^7 are each like the zone 5 of FIG.2 and form a seven zone cluster. Similarly, in FIG. 3, the zones 6^1 , 6^2 , ..., 6^7 are each like the zone 5 of FIG.2 and form a second seven zone cluster. Any number of additional zone clusters may be provided as necessary to cover any particular region. The region manager 12 of FIG. 3 functions to control the bandwidth values of the collector reverse channels in order to balance the load

among the various regions of FIG. 3 along common backhaul channels. For example, if traffic tends to move from one particular zone to another zone during certain times (such as during commute times), the bandwidth of the common backhaul channel is dynamically allocated so that the zone with higher traffic is allocated more bandwidth.

5 Multiple-Collector Configuration -- FIG. 4

In FIG. 4, a plurality of collectors 45-1, ..., 45-Nc, like the collectors 45 in FIG. 1, each receive reverse channel communications from users 15-1, ..., 15-U. For each user 15, the collectors 45-1, ..., 45-Nc each process the received signals all representing the same communication from the user 15.

10 These communications have macro-diversity because of the macro distances separating the collectors 45 of FIG. 1. These communications include spatially macro-diverse data bursts, ${}^1B_p, \dots, {}^{N_c}B_p$, and corresponding processed confidence metric vectors ${}^1CM_p, \dots, {}^{N_c}CM_p$ that are forwarded to the aggregator 17 in formatted form designated as ${}^1B_p/{}^1CM_p/{}^1M/{}^1CC, \dots, {}^{N_c}B_p/{}^{N_c}CM_p/{}^{N_c}M/{}^{N_c}CC$.

15 The aggregator 17 combines the spatially diverse data bursts ${}^1B_p, \dots, {}^{N_c}B_p$, and corresponding confidence metric vectors ${}^1CM_p, \dots, {}^{N_c}CM_p$ to form a final single representation of the data burst, B_p , with a corresponding final confidence metric vector, CM_p . The aggregator 17 may use the measurement signals ${}^1M, \dots, {}^{N_c}M$ and control signals ${}^1CC, \dots, {}^{N_c}CC$ in selecting or processing the data bursts ${}^1B_p, \dots, {}^{N_c}B_p$, and/or the corresponding confidence metric vectors ${}^1CM_p, \dots, {}^{N_c}CM_p$.

20 For example, if a particular burst is associated with a poor quality signal, the particular burst may be excluded from the aggregation. The quality of a signal is measured in one example based on the channel model attenuation estimate.

25 In FIG. 4, the collectors 45-1, ..., 45-Nc include RF subsystems 43-1, ..., 43-Nc which have two or more micro-diversity receive antennas 48-1, ..., 48-N_a. The antennas 48-1, ..., 48-N_a each receives the transmitted signals from

each one of a plurality of users 15-1, ..., 15-U. Each representation of a received signal from a single user that is received by the RF subsystems 43-1, ..., 43-N_c connects in the form of a burst of data to the corresponding one of the signal processors 42-1, ..., 42-N_c. The received data bursts from the antennas 48-1, ..., 48-N_a are represented as ${}^1B_r, \dots, {}^{N_a}B_r$. The signal processors 42-1, ..., 42-N_c process the plurality of received bursts for a single user to form single processed bursts, ${}^1B_p, \dots, {}^{N_c}B_p$, representing the signals from the single user. The processed bursts, ${}^1B_p, \dots, {}^{N_c}B_p$, have corresponding confidence metric vectors, ${}^1CM_p, {}^2CM_p, \dots, {}^{N_c}CM_p$, representing the reliability of each bit of the data bursts. Each processed burst has the bits $\beta_{p1}, \beta_{p2}, \dots, \beta_{pB}$ and the processed confidence metric vector, CM_p , has the corresponding processed confidence metrics $cm_{p1}, cm_{p2}, \dots, cm_{pB}$. Measurement signals, ${}^1M, \dots, {}^{N_c}M$, are formed that measure the power or other characteristics of the signal. The processed bursts, the confidence metric vectors, and the measurements connect to the interface units 46-1, ..., 46-N_c which format those signals and transmit or otherwise connect them as reverse channel signals to the aggregator 17.

In FIG. 4, the signal processors 42-1, ..., 42-N_c receive timing information that permits collector signals from each collector to be time synchronized with signals from each of the other collectors. For example, each collector may have a global positioning system (GPS) receiver (not shown) for receiving a time synchronization signal. Alternatively, or in addition, the zone manager 20 of FIG. 1 can broadcast or otherwise transmit time synchronization information. The signal processors 42-1, ..., 42-N_c provide time stamps in collector control signals ${}^1CC, \dots, {}^{N_c}CC$ that are forwarded from interface units 46-1, ..., 46-N_c as part of the reverse channel signals to the aggregator 17.

In FIG. 4, a block diagram representation of the aggregator 17 is shown. The aggregator 17 includes a receive/format group 66 which operates to receive and format signals transmitted by the collectors 45. The received signals ${}^1B_r / {}^1CM_p / {}^1M / {}^1CC, {}^2B_r / {}^2CM_p / {}^2M / {}^2CC, \dots, {}^{N_c}B_r / {}^{N_c}CM_p / {}^{N_c}M / {}^{N_c}CC$, after

formatting are connected to the signal processor 67 which processes the received signals for macro-diversity combining. The format group 66 uses the time stamp and other control code (CC) information to align the signals from different collectors for the same user. More specifically, the unit 66 for each one or more bursts compares and aligns the time stamps from the control fields ${}^1\text{CC}$, ${}^2\text{CC}$, ..., ${}^{N_c}\text{CC}$ so that the corresponding data, confidence metric and measurement signals from different collectors, for the same common burst from a user are aligned.

The signal processor 67 for the aggregator 17 processes the burst signals from each user and the N_c representations of the reverse channel signal from the user as received through the N_c active collectors 45. The N_c data, metric and measurement values for a single user include the data and processed confidence metric pairs [${}^1\text{B}_b$, ${}^1\text{CM}$], [${}^2\text{B}_b$, ${}^2\text{CM}_p$], ..., [${}^{N_c}\text{B}_b$, ${}^{N_c}\text{CM}_p$] and the measurement values, ${}^1\text{M}$, ${}^2\text{M}$, ..., ${}^{N_c}\text{M}$. The processed confidence metrics, ${}^1\text{CM}_p$, ${}^2\text{CM}_p$, ..., ${}^{N_c}\text{CM}_p$ are processed to form the aggregator processed confidence metrics, ${}^1\text{CM}_{pp}$, ${}^2\text{CM}_{pp}$, ..., ${}^{N_c}\text{CM}_{pp}$.

Co-sited Collectors--FIG. 5

FIG. 5 shows an embodiment in which the collectors 45 are co-sited with the broadcasters 16 and aggregators 17 of zone managers 20 of FIG. 2. In FIG. 5, six zone managers ZM1, ZM2, ZM3, ZM4, ZM5 and ZM6 are distributed over a community where the mobile users tend to be concentrated along the roadways 22 (designated by bold lines). The zone managers ZM1 and ZM5 are omni-directional and the zone managers ZM2, ZM3, ZM4 and ZM6 are sectorized. The zone manager ZM2 has sectors 2-1 and 2-2, the zone manager ZM3 has sectors 3-1 and 3-2, the zone manager ZM4 has sectors 4-1 and 4-2 and the zone manager ZM6 has sectors 6-1 and 6-2. Each sector has a broadcaster 16 (not shown) and a pair of micro-diverse collectors 45 (not shown) for broadcasting and receiving over a sector zone. For example, the sector zone 21 for sector 2-1 of zone manager ZM2 and the sector zone 41 for sector 4-1 of

zone manager ZM4 are shown by way of example in FIG. 5. Also, zone 11 is partially shown in FIG. 5 representing the omni-directional zone of zone manager ZM1. A user 15 receives broadcasts, for example, from anyone of the zone managers ZM1, ZM2 or ZM4. A particular one of the zone managers ZM1, ZM2 or ZM4 is selected as the active one for the user 15 and that active zone manager broadcasts on a unique forward broadcast channel. The user 15 in turn broadcasts on a corresponding reverse channel. The zone managers ZM1, ZM2 and ZM4 each include micro-diverse collectors for receiving the user broadcasts regardless of which one of the broadcasters from the zone managers ZM1, ZM2 or ZM4 is active for the particular user.

When user 15 moves to a new location as shown by 15', the zone managers ZM1, ZM2 and ZM4 may or may not hand-off the broadcast frequency from one zone manager to another. For example, in moving from the user 15 location to the user 15' location, if the broadcaster for zone manager ZM4 is active, then that broadcaster may remain active even though the user 15 moves. If the broadcaster forward channel remains the same, then the user 15 reverse channel remains the same. However, the collector group receiving the reverse channel may change. For example, at the user 15 location, the active collectors can be collectors for sector 2-1 of ZM2, sector 4-1 of ZM4 and collectors for ZM1. At the user 15' location, the active collectors may be from sector 2-2 of ZM2, sector 3-1 of ZM3 and sector 4-1 of ZM4.

In another example, in moving from the user 15 location to the user 15' location, if the broadcaster for zone manager ZM2 sector 2-1 is active, then the broadcaster for one zone manager may change with a hand-off to the broadcaster for another zone manager as a result of the user 15 move. If the broadcaster forward channel changes, then the collector reverse channel correspondingly changes and the collector group receiving the user reverse channel changes frequency. For example, at the user 15 location, the active collectors can be collectors for sector 2-1 of ZM2, sector 4-1 of ZM4 and collectors for ZM1 at

one reverse channel frequency. At the user 15' location, the active collectors may be from sector 2-2 of ZM2, sector 3-1 of ZM3 and sector 4-1 of ZM4 at a different reverse channel frequency than for the user at the user 15 location.

Communication Layout for FIG. 5 Region — FIG. 6

In FIG. 6, the communication layout for the region of FIG. 5 is shown. Each zone manager includes an XTS unit with a processor and T1 communications and an X unit with information packet (IP) routing facilities. In the embodiment shown, the communications for the region are between the region manager and the zone manager ZM4 which in turn relays information for the other zone managers.

Typical Zone Manager — FIG. 7

In FIG. 7, further details of a typical zone manager of FIG. 5 and FIG. 6 are shown. Each zone manager includes a broadcaster B_j , an aggregator A_j , and a collector group C_j . The collector group for zone manager ZM4 includes for sector 4-1 a micro-diverse collector pair at zone manager ZM4, the micro-diverse collector pair at ZM2 for sector 2-1, and a micro-diverse collector pair at ZM1. The collectors in a group are macro-diverse in that they are located at the macro-diverse locations of the different zone managers.

Zone Manger of FIG. 5 Region — FIG. 8

In FIG. 8, the zone managers ZM1, ..., ZM6 are shown each with a broadcaster, an aggregator and a collector group where each collector group is formed of macro-diverse collectors including collectors at other ones of the zone managers. The collector groups for the zone managers ZM6, ..., ZM1 have the zone manager collector aggregation as shown in the following TABLE 1.

Zone Manager Collector Group	Zone Manger Aggregation
6	6, 5
5	6, 5, 3
4	4, 2, 1
3	5, 3, 2
2	4, 2, 1
1	4, 2, 1

While the invention has been particularly shown and described with reference to preferred embodiments thereof it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

CLAIMS

1. A communication system having a plurality of forward channel communications and a plurality of corresponding reverse channel communications comprising,

a region manager means for communicating said plurality of forward channel communications and a plurality of corresponding reverse channel communications in a region,

a plurality of zone manager means in said region each including,

broadcaster means having a broadcaster transmitter for broadcasting said plurality of forward channel communications using broadband broadcaster signals to form a plurality of broadcaster forward channels,

aggregator means for processing reverse channel communications,

collector means for receiving reverse channel communications and forwarding reverse channel communications to said aggregator means,

a plurality of users,

each of said users including user receiver means for receiving a different forward channel from said broadcaster means and including user transmitter means for broadcasting user reverse channel communications in a different user reverse channel,

the improvement characterized by:

said broadcaster means broadcasting said plurality of broadcaster forward channels in a broadcaster zone,

said plurality of users, located in said broadcaster zone, for providing a plurality of different user reverse channels collectively as a broadband composite signal,

a plurality of said collector means distributed over said broadcaster zone at macro-diverse locations so that each of said plurality of collector means is

active to receive said composite signal over at least a portion of said broadcaster zone and so that user reverse channels for some ones of said plurality of users are received by two or more of said collector means,

each of said collector means including broadband collector receiver means for receiving said broadband composite signal with reverse channel communications from ones of said plurality of users, and each of said collector means including collector forwarding means for forwarding, to said aggregator means, said user reverse channel communications from said ones of said plurality of users as collector reverse channel communications,

said aggregator means for receiving said collector reverse channel communications from said collector means to provide said corresponding reverse channel communications for each of said ones of said plurality of users as a combination of the collector reverse channel communications from said two or more collector means.

2. The communication system of Claim 1 including a region manager means for communicating between a network and a region with a plurality of network forward channel communications from the network to said broadcaster means and with a plurality of corresponding network reverse channel communications to the network from said aggregator means.

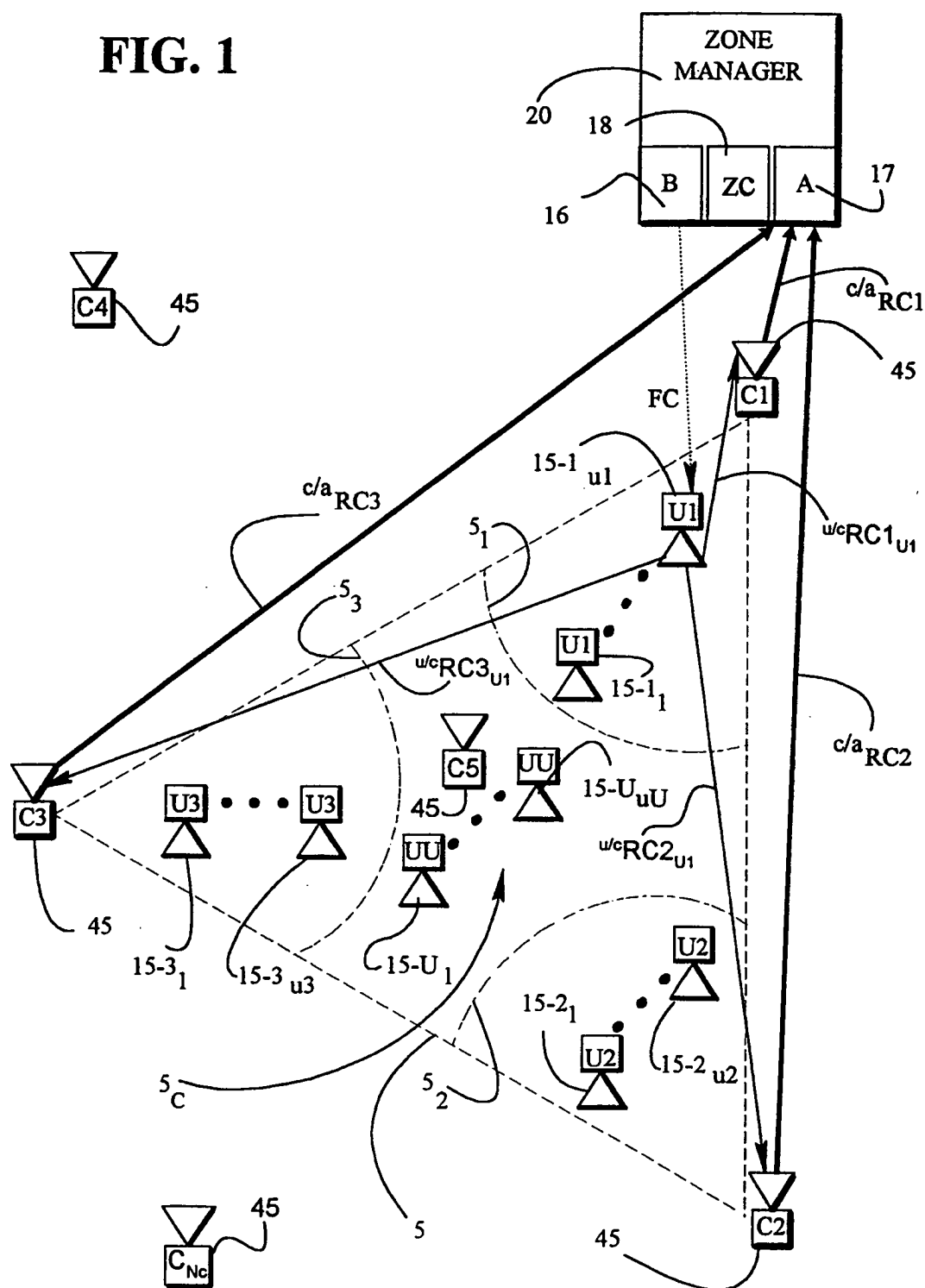
3. The communication system of Claim 1 wherein a particular user is one of said users and travels from a first one of said broadcaster zones to a second one of said broadcaster zones and wherein said region manager means includes control means for assigning a first broadcaster forward channel and a first user reverse channel for said particular one of said users for said first zone and for assigning a second broadcaster forward channel and a second user reverse channel for said particular one of said users for said second zone.

4. The communication system of Claim 1 wherein for one of said zone manager collectors means are co-located with said broadcaster means for said one of said zone manager means and wherein other collectors means are located at macro-diverse locations from said one of said zone manager means.

5. The communication system of Claim 4 wherein said other collectors means are co-located with broadcasts means of other of said zone manager means.

6. The communication system of Claim 1 wherein ones of said collector means use directional antenna means.

FIG. 1



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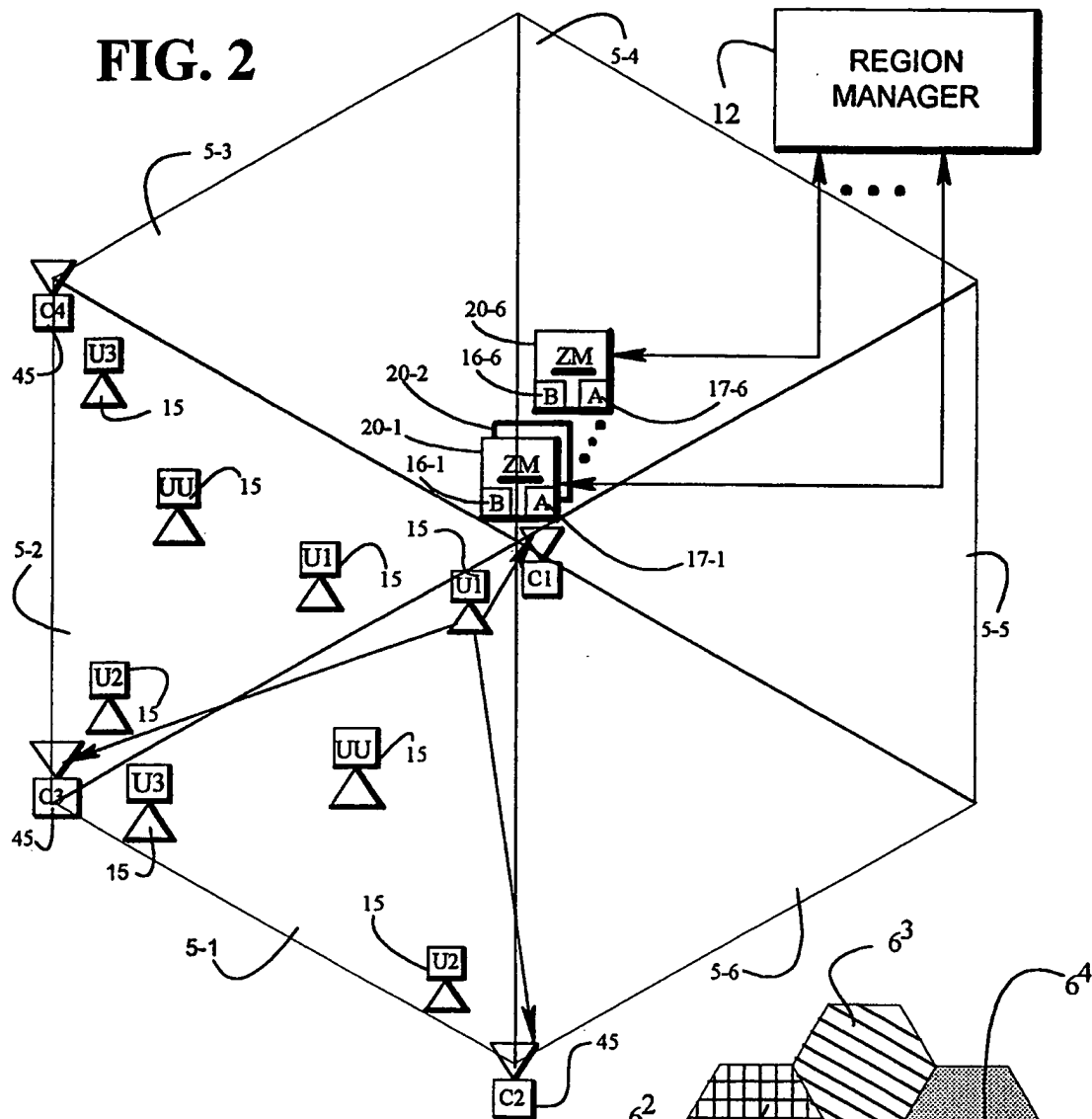
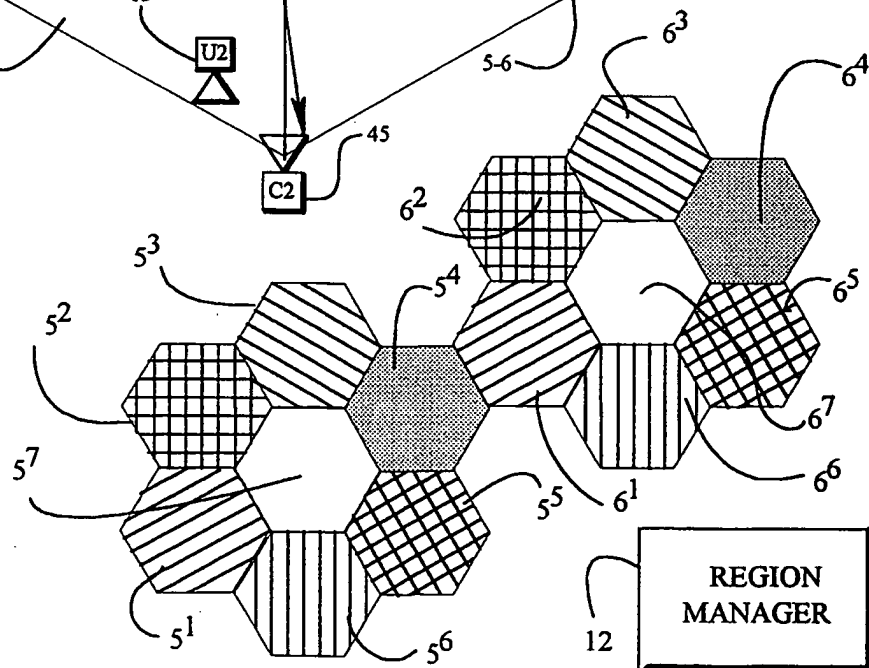
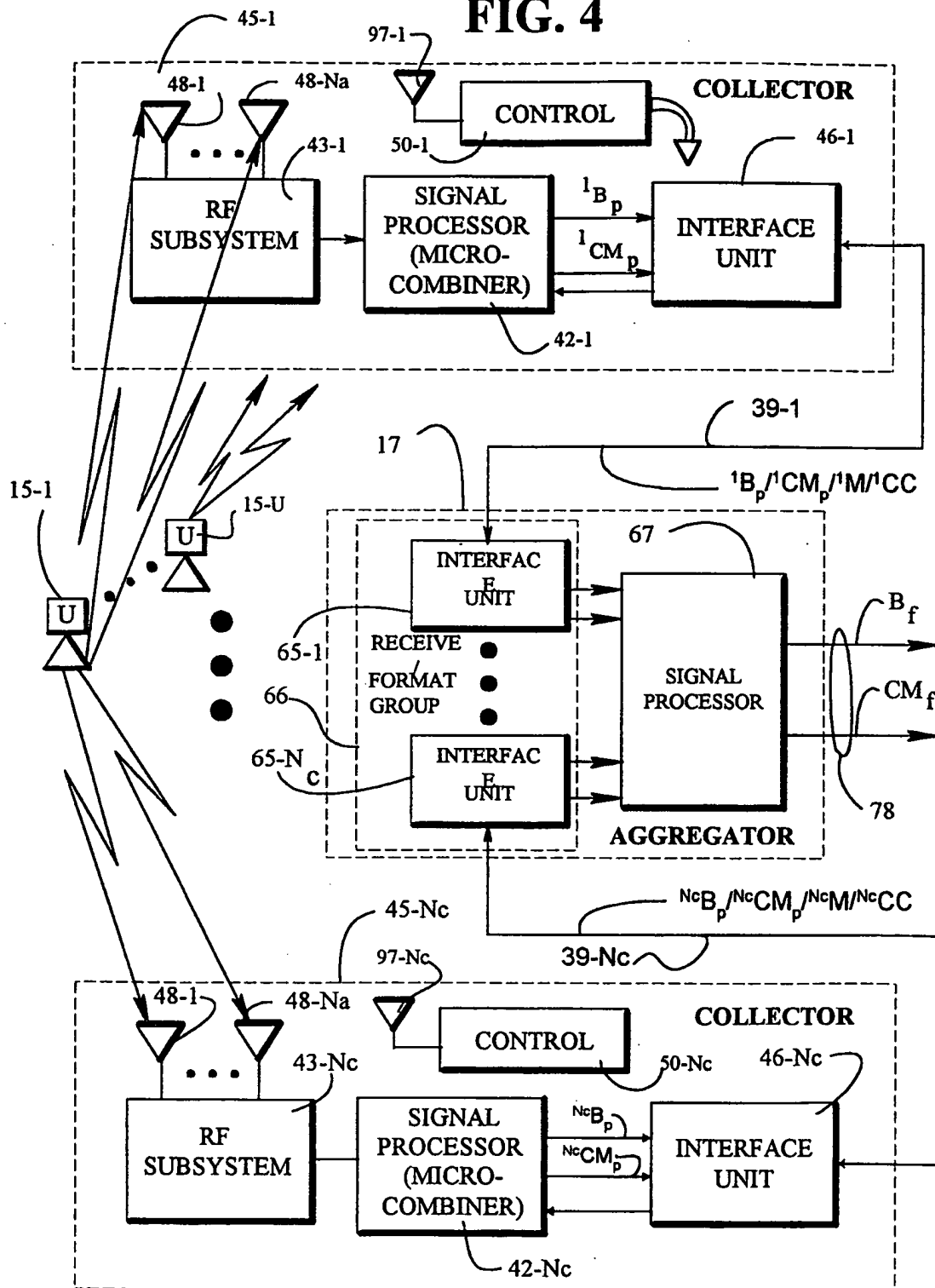


FIG. 3



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FIG. 4



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FIG. 5

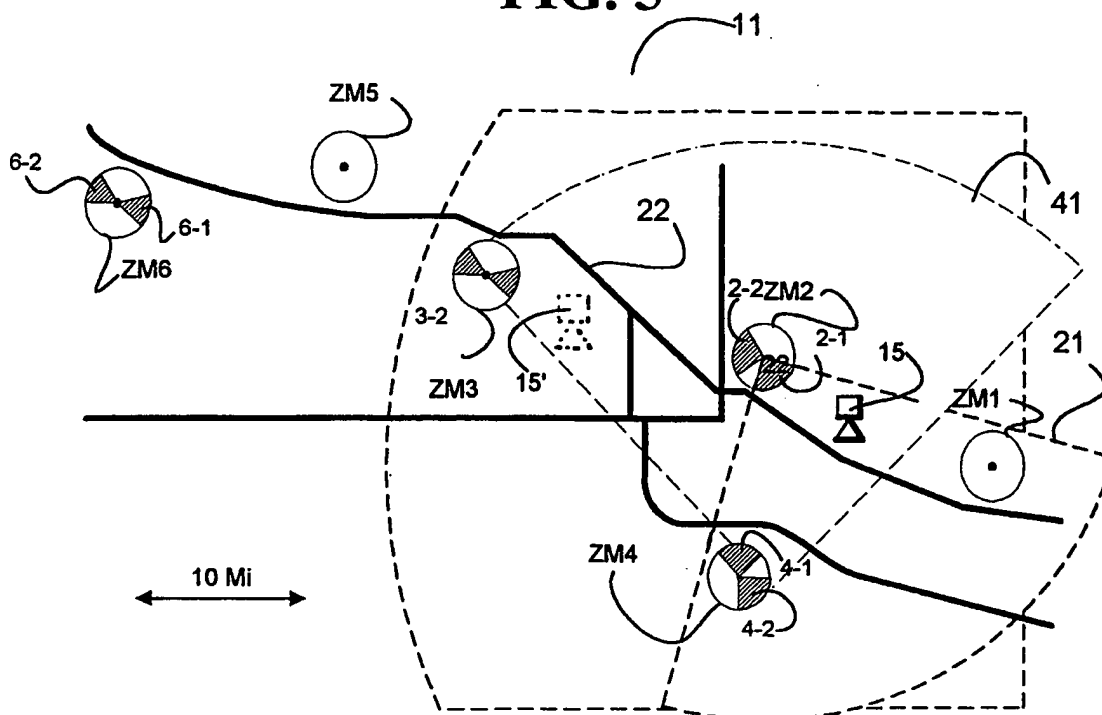
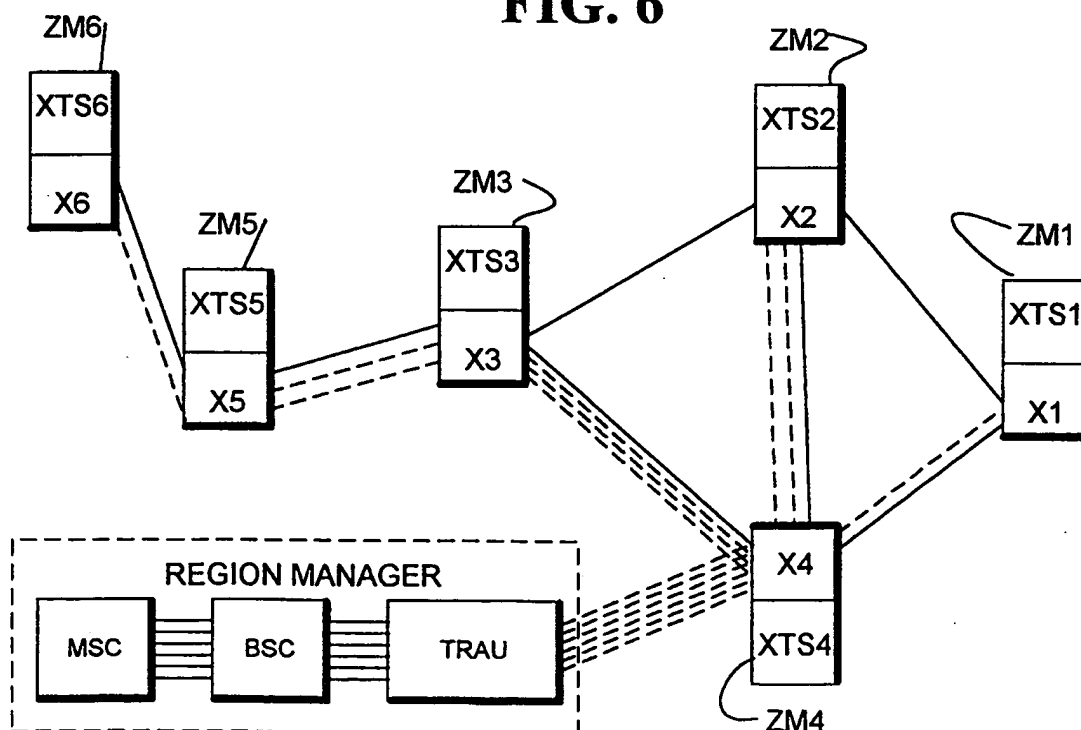


FIG. 6



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FIG. 7

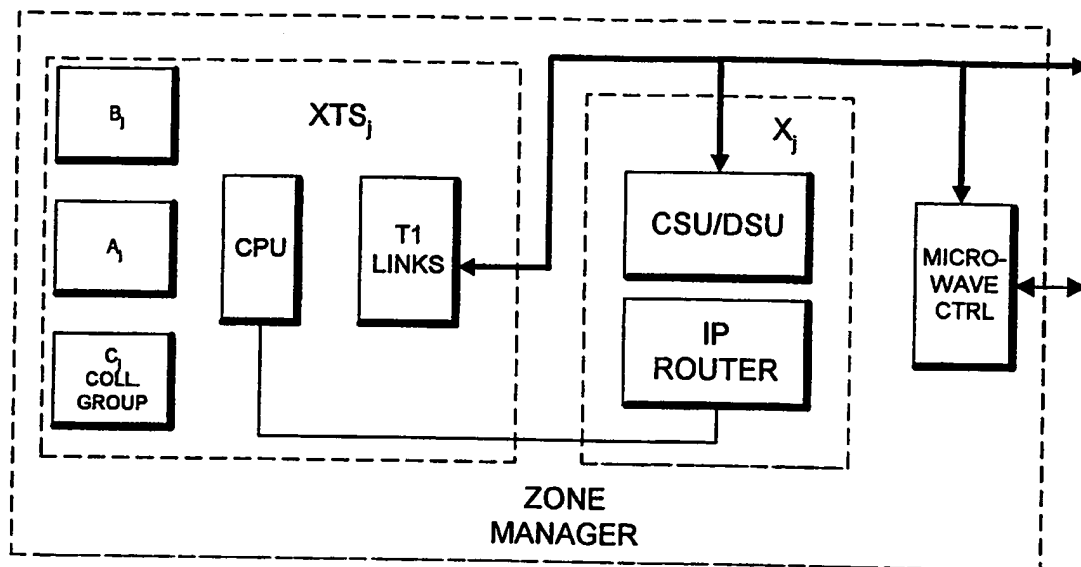
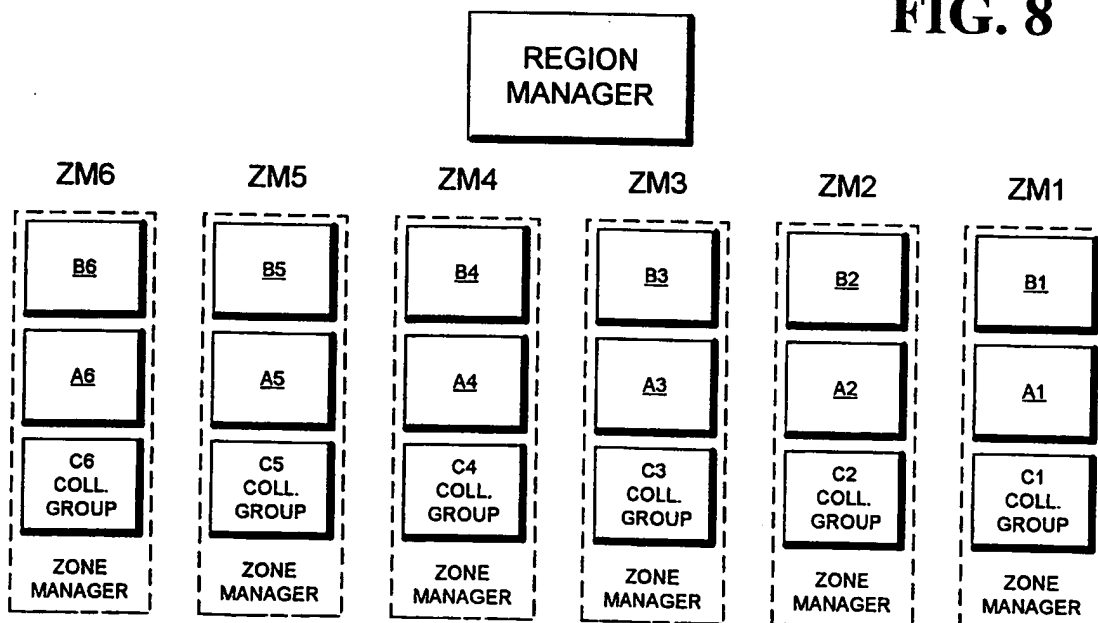


FIG. 8



INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/01931

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/04 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 15159 A (CELLULAR TELECOM LTD) 24 April 1997 * abstract * see page 17, line 12 - page 20, line 18 see claim 1; figure 2 ---	1
X	WO 97 40639 A (CELLULAR TELECOM LTD) 30 October 1997 * abstract * see page 9, line 1 - line 15 see page 10, line 3 - line 7 see claims 1,12,24,34; figures 1,5 --- -/--	1

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search

20 May 1999

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 99/01931

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	<p>WO 98 36509 A (CELLULAR TELECOM LTD) 20 August 1998 * abstract * see page 9, line 21 - page 11, line 10 see claims 1,2,26,50,55,63; figures 1,2,4-9</p> <p style="text-align: center;">----</p>	1
A	<p>EP 0 702 462 A (AT & T CORP) 20 March 1996 * abstract * see column 2, line 11 - column 3, line 36 see column 5, line 18 - column 6, line 52 see column 9, line 17 - line 25 see figure 1</p> <p style="text-align: center;">----</p>	1
A	<p>EP 0 622 911 A (IBM) 2 November 1994 * abstract * see column 2, line 12 - column 3, line 11 see column 3, line 34 - column 4, line 29 see column 6, line 6 - line 47 see claim 1; figures 1,2,5</p> <p style="text-align: center;">-----</p>	1

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Information on patent family members

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